



# **Distributed Power Program Overview: Interconnection & System Integration R&D**

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# Mission



The Distributed Power Program conducts RD&D on interconnection and system integration technologies and on regulatory policies to remove Technical, Institutional and Regulatory barriers impeding realization of the full potential of distributed energy resources.

# Goals

- Reduce interconnection & system integration costs
- Reduce hassle factor
- Achieve full benefits and value for DER

## Reduce Technical Barriers

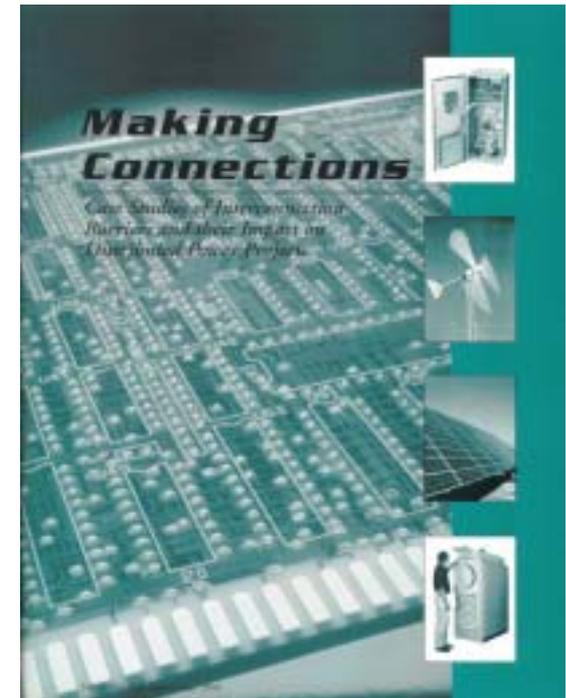
- (1) Adopt uniform technical standards for interconnecting distributed power to the grid.
- (2) Adopt testing and certification procedures for interconnection equipment.
- (3) Accelerate development of distributed power control technology and systems.

## Reduce Business Practice Barriers

- (4) Adopt standard commercial practices for any required utility review of interconnection.
- (5) Establish standard business terms.
- (6) Develop tools for utilities to assess the value and impact of distributed power.

## Reduce Regulatory Barriers

- (7) Develop new regulatory principles compatible with distributed power choices in both competitive and utility markets.
- (8) Adapt regulatory tariffs and utility incentives to fit the new distributed power model.
- (9) Establish expedited dispute resolution processes for distributed generation project proposals.
- (10) Define the conditions necessary for a right to interconnect.





# Program Strategy



- Technical Standards
  - Interconnection with electric power system
  - Electrical/Fire/Mechanical Safety
  - Data/Communications
  - Software
  - Architecture/Modularization/Physical connection
- System Integration R&D
  - Increase component integration
  - Develop cost-effective advanced plug-and-play interconnection and control technologies
  - Enhance capability to integrate, interact, and provide operational benefits
    - Enterprise energy management systems and resource planning
    - Grid support, ancillary services, and load/demand management
    - Adaptive, intelligent technology
- Mitigation of Regulatory and Institutional Barriers
  - Utility interconnection and related tariffs
  - Emissions regulations
  - Local siting and permitting

- Reduce the cost of interconnection hardware by 15% by 2005 and 30% by 2010.
- Modular universal plug-and-play interconnection technology by 2010
- National interconnection standard in 2002 & major revision by 2007
- UL/ANSI standard and certification process to cover interconnection equipment for all DG by 2003
- Model emissions rule for small DG by 2003



# Program Achievements



- December 1998 Workshop
- DP Program Initiated in January 1999
- Initiation of IEEE P1547 DER Interconnection Standard Project in March 1999
- First Program Review in December 1999
- Publication of *Making Connections* in May 2000
- Workshop on RTO/ISO issues FY 2000
- System Integration R&D Solicitation Awards in FY 2000/2001
- Interconnection Technologies Workshop July 2001
- Ballot on draft IEEE interconnection standard March 2001 and recirculation in September 2001



# Program Achievements



- NREL DER interconnection/system integration test facility operational November 2001
- Pilot field test of interconnection requirements conducted at Nevada Test Site in November 2001
- DTE and GE modeling of grid impacts
- 4 workshops for state utility regulators in FY 2000/ 2001
- Reports on regulatory issues September 2001
- 6 workshops for local code officials in FY 2001/2002
- Draft model emissions rule for public comment November 2001



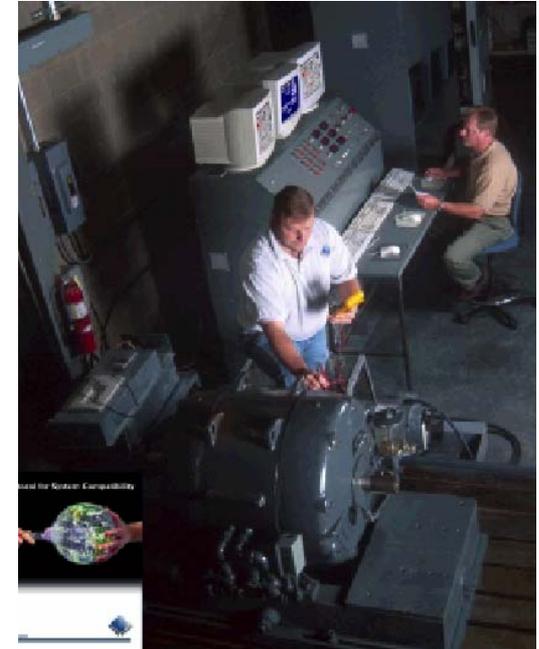
# Technical Standards



- IEEE P1547 Standard for Distributed Resources Interconnected with Electric Power Systems
- Communications and Other Standards
- Expanded UL 1741 to Include all DG Interconnection Technologies
- Development of Certification Process
- Modeling DG Interactions and Impacts on Grid
- Laboratory and Field Testing
  - National Renewable Energy Laboratory
  - Nevada Test Site
  - Distributed Utility Integration Test

- UL1741 New Title – “The Standard For Inverters, Converters and Controllers For Use In Independent Power Production Systems”
- Expansion to cover the interconnect of all types of DER
  - Controllers for rotating generators
  - Requirements for other static DER technologies
- Additional procedures needed for new IEEE P1547 requirements
  - Surge withstand
  - Synchronization and loss of
  - Immunity protection
  - Flicker
  - Field verification test capability

- Define a certification and lab accreditation process, demonstrate their application in a pilot effort and draft an implementation plan:
  - certification and labeling criteria
  - test protocols and test results
  - handbook on interconnection agreements
  - web-based information hotline and technical training materials

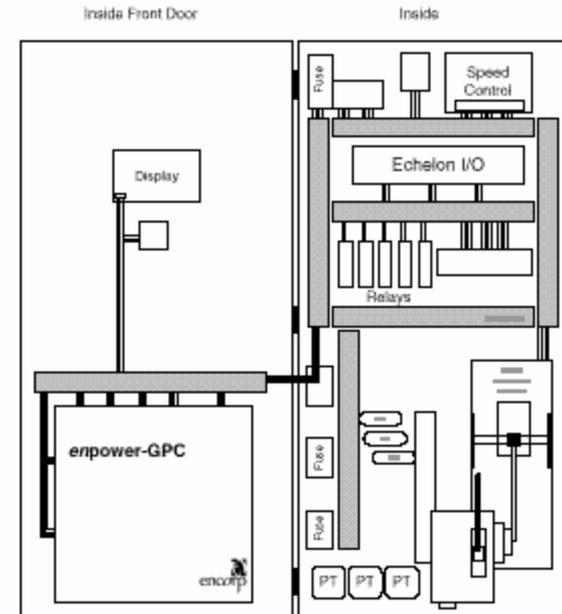


## EPRI-PEAC

Dynamic Performance  
Electro- Magnetic Compatibility  
Surge Test  
Power quality and reliability studies

- Universal plug-and-play interconnection system
  - Inverter-based plug-and-play across multiple technologies
  - Fully integrated utility-grade switchgear, metering, and system-level command and control for synchronous machines <500kW
- Enterprise energy management technology
  - Aggregation
  - Microgrids
- Automated adaptive intelligent interconnection and control
- Modeling
- Laboratory and Field Testing

- Improved and Expanded Protective Relay Performance
- Increased EMI and Surge Withstand Immunity
- Revenue Grade Metering
- Expanded Suite of Communication Options To Enable Flexible Inter-Device & Network Connectivity
- Accept Multiple Power Sensors
- Data Logging and Sequence of Events Logging
- Alarming, Trending, and Wave Form Capture



## Examples

- Synchronizer (frequency, phase, and voltage matching)
- Import/export control (with fully-automated peak shaving)
- Isochronous kW load sharing control
- Reverse-phase/phase-balance current
- Base load control
- VAR/Power Factor control
- Phase sequence voltage
- Voltage-restrained overcurrent
- Over/under-voltage for generator breaker and utility tie breaker
- Over/under-frequency for generator breaker and utility tie breaker
- “Soft” loading and unloading control
- Digital power metering, monitoring
- Automatic transfer switch control
- Sync check
- Auto-synchronizer
- Directional power
- Directional reactive power



# Advanced Plug-and-Play Interconnection



	Local Interfaces		Microprocessor Based Power Conditioning, Control, Communications	External Interfaces	
PV	Power	DER	Power Conversion/ Conditioning	Grid (Power)	Utility Microgrid
Wind					
Gas Turbine	C3	DER	Protection	Grid (Power)	Utility Microgrid
Gas Engine					
Microturbine	Power	Load	DER and Load Control	Control (C3)	Remote Enterprise Management Aggregator
Fuel Cell					
Storage	C3	Load	DER and Load Control	Control (C3)	Aggregator
AC Loads					
DC Loads	Power	Sensors	Ancillary Services	Control (C3)	Utility
Temperature					
Motion	C3	Sensors	Ancillary Services	Control (C3)	Utility
Detection					
Alarms	Power	Sensors	Ancillary Services	Control (C3)	Utility
PC					
Workstation	C3	Control	Revenue Grade Metering	Data (C3)	Electricity Markets
	C3	Control	Communications	Data (C3)	Weather

- Web based network energy information
- Supports real-time data collection
- Forecasts load and generation
- Energy system optimization
- Aggregate commodity purchasing
- Sale of services to the grid

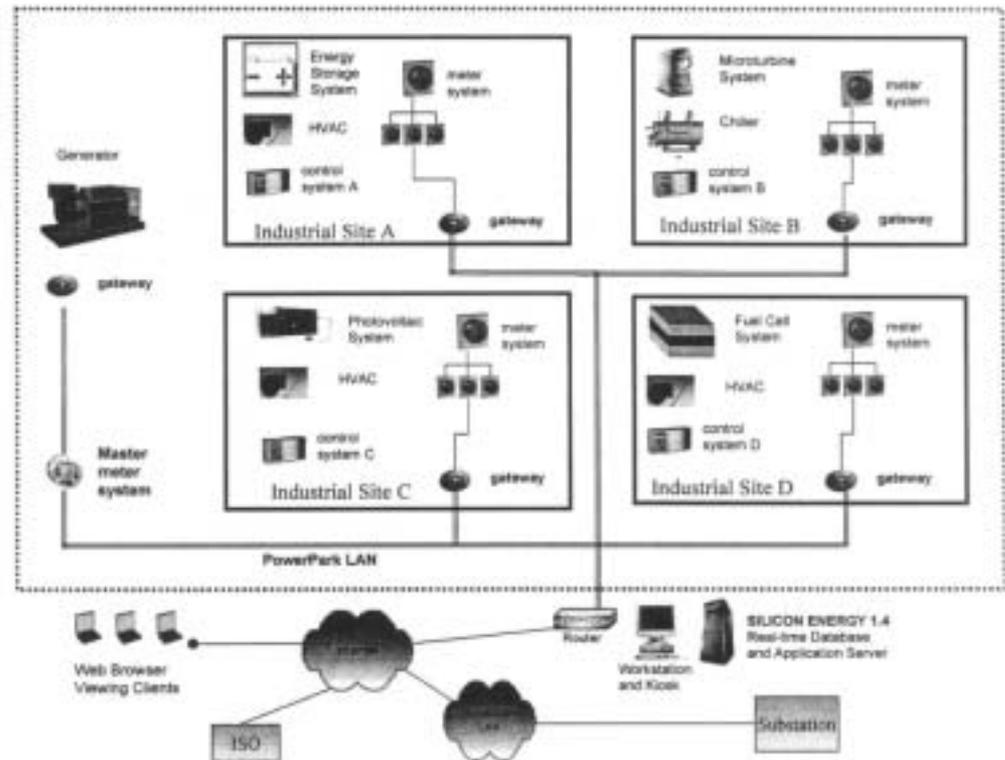


Figure 1 Enterprise Energy Management and Dispatch Control Software



# Regulatory & Institutional Barriers



- **Utility Regulation**

- Working with NARUC and States developing interconnection rules
- Tariffs: back-up charges, exit fees, uplift fees, incentive rates, etc

- **Local Codes and Standards**

- PTI/Urban Consortium Action Plan
- DER Road Show
- Training video
- Handbook for local inspectors

- **Environmental Regulation**

- Environmental Barriers Case Studies
- Model Rule for Small DG
  - RAP, State regulators, EPA, DG industry



# Program Participants



Caterpillar

Competitive Utility Strategies

Detroit Edison Co.

Distributed Utility Associates

DTE Energy Technologies

Electric Power Research Institute

Electrotek

Encorp

Endecon Engineering

Energy Signature Associates, Inc.

Exelon Corp

Gas Research Institute

General Electric Corporate R&D

Kelso Starrs and Associates

Kinectrics Incorporated

Long island Power Authority

National Rural Electric Cooperative Association

NiSource Energy Technologies, Inc

Onsite/Syscom

Orion Engineering Corp.

Pacific Gas and Electric Co

RealEnergy

RLB Communications

Spire Solar Chicago

Silicon Energy

The Regulatory Assistance Project

Underwriters Laboratories Inc.

California Energy Commission

New York State Energy R&D Authority

Colorado School of Mines

University of Massachusetts Lowell

University of Wisconsin- Madison



# DOE Interaction



- Participation:
  - National Labs: NREL (lead lab), INEEL, ORNL
  - Golden Field Office
  - Nevada Operations Office/Nevada Test Site
- Coordination:
  - National Labs: PNNL, SNL, LBNL
  - Regional Offices
  - PV, Wind, CHP, Fuel Cell, Microturbine Programs
  - CERTS



# Planned FY 2002 Milestones



- Approved interconnection standard
- Draft revised UL 1741
- Prototype enhanced interconnection system
- Environmental barriers report
- Additional workshops for utility regulators
- Additional workshops for local code officials
- Test plan
- Updated 5-year plan



# DPP Website



[www.eren.doe.gov/distributedpower/](http://www.eren.doe.gov/distributedpower/)